WE CLAIM:

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1. An electrical current generating system, comprising:

at least one fuel cell operating at a temperature of at least about 250°C;

at least one gas system selected from a hydrogen gas separation system or oxygen gas delivery system coupled to the fuel cell, the hydrogen gas delivery system or oxygen gas delivery system including at least one device selected from a compressor or pump; and

a drive system for the compressor or pump that includes means for recovering energy from at least one of the hydrogen gas separation system, oxygen gas delivery system, or heat of the fuel cell.

2. The system according to claim 1, wherein the fuel cell is a molten carbonate fuel cell or a solid oxide fuel cell.

3. The system according to claim 1, wherein the fuel cell is operated at a temperature of at least about 600°C.

4. The system according to claim 1, wherein the means for recovering energy comprises at least one system selected from a gas turbine, heat exchanger, or Stirling engine.

5. The system according to claim 1, wherein the hydrogen gas separation system or oxygen gas delivery system includes a pressure swing adsorption module.

6. The system according to claim 1, wherein the pump comprises a vacuum pump.

7. An electrical current generating system, comprising:

at least one fuel cell operating at a temperature of at least about 250°C;

at least one gas system selected from a hydrogen gas separation system or oxygen gas delivery system coupled to the fuel cell; and

a gas turbine system coupled to the hydrogen gas separation system or oxygen gas delivery system, wherein the gas turbine system is powered by energy recovered from at least one of the hydrogen gas separation system, oxygen gas delivery system, or heat of the fuel cell.

8. The system according to claim 7, wherein the hydrogen gas separation system or oxygen gas delivery system includes a pressure swing adsorption module.

9. The system according to claim 8, wherein the pressure swing adsorption module can deliver a hydrogen-containing gas to the fuel cell, the pressure swing adsorption module including a first adsorbent and at least one second material selected from a second adsorbent, a steam reforming catalyst, or a water gas shift reaction catalyst.

10. The system according to claim 9, wherein the first adsorbent preferentially adsorbs carbon dioxide compared to water vapor.

11. The system according to claim 10, wherein the first adsorbent comprises an alkali-promoted material and the catalyst comprises a Cu-ZnO catalyst, a transition metal carbonyl complex catalyst, or a catalyst comprising a transition group metal inserted into a zeolite cage.

12. The system according to claim 7, wherein the gas turbine system is further coupled to at least one device selected from a compressor, a pump, or an auxiliary device.

13. An electrical current generating system, comprising:

at least one fuel cell selected from a molten carbonate fuel cell or a solid oxide fuel cell;

at least one gas system selected from a hydrogen gas separation system or oxygen gas delivery system coupled to the fuel cell; and

a gas turbine system coupled to the hydrogen gas separation system or oxygen gas delivery system, wherein the gas turbine system is powered by energy recovered from at least one of the hydrogen gas separation system, oxygen gas delivery system, or heat of the fuel cell.

14. An electrical current generating system, comprising:

at least one fuel cell operating at a temperature of at least about 250°C;

at least one gas system selected from a hydrogen gas separation system or oxygen gas separation system coupled to the fuel cell, wherein the hydrogen gas separation system can produce a first exhaust gas stream and the oxygen gas separation system can produce a second exhaust gas stream; and

a gas turbine system coupled to at least one of the hydrogen gas separation system or oxygen gas separation system, wherein the gas turbine system receives at least one of the first exhaust gas stream or second exhaust gas stream.

15. The system according to claim 14, wherein the fuel cell operates at a temperature of at least about 600°C.

16. The system according to claim 14, wherein the hydrogen gas separation system comprises a first adsorption module and the first exhaust gas stream is enriched in carbon dioxide.

17. The system according to claim 16, further comprising a combustor that defines a first inlet for receiving the first exhaust gas stream and an outlet for discharging a combustion product gas stream.

18. The system according to claim 17, further comprising a first conduit fluidly coupling the combustor outlet and a cathode inlet defined by the fuel cell, a second conduit fluidly coupling a cathode outlet defined by the fuel cell and the gas turbine system, and at least one heat exchanger housing at least a portion of the first conduit and at least a portion of the second conduit.

19. The system according to claim 17, further comprising at least one conduit fluidly coupling the combustor outlet and the gas turbine system.

20. The system according to claim 14, wherein the gas turbine system includes at least one device selected from a compressor and a vacuum pump.

21. The system according to claim 16, wherein the first adsorption module comprises a rotary pressure swing adsorption module.

22. The system according to claim 21, wherein the gas turbine system includes at least one device coupled to the rotary pressure swing adsorption module, the device being selected from a compressor and a vacuum pump.

23. An electrical current generating system, comprising:

at least one fuel cell selected from a molten carbonate fuel cell and a solid oxide fuel cell;

at least one pressure swing adsorption module that can produce an oxygen-enriched gas stream for delivery to the fuel cell, and a heavy product exhaust gas stream; and

at least one vacuum pump coupled to the pressure swing adsorption module for extracting the heavy product gas stream.

24. An electrical current generating system, comprising:

an oxygen-containing gas source;

at least one hydrogen gas separation module that can produce a hydrogen-enriched gas stream and a carbon dioxide-enriched gas stream;

a combustion device for producing a combustion product gas stream from the oxygen-containing gas and the carbon-dioxide enriched gas stream; and

at least one molten carbonate fuel cell having a cathode inlet for receiving the combustion product gas stream and an anode inlet for receiving the hydrogen-enriched gas stream.

25. The system according to claim 24, wherein the hydrogen gas separation module comprises a pressure swing adsorption module.

26. The system according to claim 24, further comprising a pressure swing adsorption module coupled to the oxygen-containing gas source that can produce an oxygen-enriched gas stream for delivery to the combustion device.

27. The system according to claim 24, wherein the molten carbonate fuel cell has an outlet for discharging at least one fuel cell exhaust gas stream, the system further comprising a first heat exchanger that receives the fuel cell exhaust gas stream and the combustion product gas stream.

28. The system according to claim 27, further comprising a hydrogen gas-generating reactor and a conduit for delivering a hydrocarbon fuel/water mixture to the hydrogen gas-generating reactor, wherein at least a portion of the hydrocarbon fuel/water mixture conduit is disposed within the first heat exchanger.

29. The system according to claim 28, further comprising a pressure swing adsorption module coupled to the oxygen-containing gas source that can produce an oxygen-enriched gas stream for delivery to the hydrogen gas-generating reactor.

30. An electrical current generating system, comprising:

at least one fuel cell having an anode outlet for discharging an anode exhaust gas and a cathode inlet, the fuel cell operating at a temperature of at least about 250°C;

a pressure swing adsorption module that can produce an oxygen-enriched gas stream; and

a combustion device for producing a combustion product gas stream from the oxygen-enriched gas stream and the anode exhaust gas; and

a conduit fluidly coupling the combustion device and the fuel cathode inlet for delivering the combustion product gas stream to the fuel cell cathode.

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31. A process for providing at least one feed stream to at least one fuel cell operating at a temperature of at least about 250°C, comprising:

providing at least one of a hydrogen gas separation system or oxygen gas delivery system coupled to the fuel cell, the hydrogen gas delivery system or oxygen gas delivery system including at least one device selected from a compressor or vacuum pump;

recovering energy from at least one of the hydrogen gas separation system, oxygen gas delivery system, or heat of the fuel cell; and

operating the compressor or vacuum pump at least partially with the recovered energy to provide at least one feed stream to the fuel cell.

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32. The process according to claim 31, wherein the energy recovering and operating comprise introducing at least one exhaust stream from the fuel cell, hydrogen gas separation system, or oxygen gas delivery system into at least one apparatus selected from a heat exchanger and a gas turbine.

33. The process according to claim 31, wherein the fuel cell is operated at a temperature of at least about 600°C.

34. The process according to claim 31, wherein the hydrogen gas separation system or oxygen gas delivery system comprises a pressure swing adsorption module.

35. A process for providing at least one fuel stream to at least one fuel cell operating at a temperature of at least about 250°C, comprising:

establishing a first pressure swing in a first fuel-containing gas stream under conditions sufficient for separating the first fuel-containing gas stream into a first fuel-enriched gas stream and a first fuel-depleted gas stream;

introducing at least one of the first fuel-enriched gas stream or the first fuel-depleted gas stream into a first apparatus for establishing the first pressure swing; and

introducing the first fuel-enriched gas stream into the fuel cell.

36. The process according to claim 35, wherein the first pressure swing establishing comprises pressure swing adsorption, the first fuel-containing gas stream comprises a hydrogen-containing gas stream, the fuel-enriched gas stream comprises a hydrogen-enriched gas stream,

the fuel-depleted gas stream comprises a carbon dioxide-enriched gas stream, and the apparatus introducing comprises introducing the carbon dioxide-enriched gas stream into a gas turbine as a working fluid for effecting the pressure swing adsorption.

37. A process for providing an oxygen-containing gas stream and a carbon dioxide-containing gas stream to a cathode of a molten carbonate fuel cell, and a hydrogen-containing gas stream to an anode of the fuel cell, comprising:

separating a hydrogen-containing gas stream into a hydrogen-enriched gas stream and a carbon dioxide-enriched gas stream;

combusting a mixture of the carbon dioxide-enriched gas stream and an oxygen-containing gas stream to provide a combustion product gas stream;

introducing the hydrogen-enriched gas stream into the fuel cell anode; and

introducing the combustion product gas stream into the fuel cell cathode.

38. The process according to claim 37, wherein the separating occurs via pressure swing adsorption.

39. The process according to claim 37, further comprising oxygen-enriching an air feed stream to produce the oxygen-containing gas stream.

40. The process according to claim 39, wherein the oxygen-enriching comprises introducing the air feed stream into a pressure swing adsorption module to produce an oxygen-enriched gas stream.

41. The process according to claim 37, wherein the fuel cell discharges at least one fuel cell exhaust gas stream, the process further comprising transferring heat from the combustion product gas stream to the fuel cell exhaust gas stream.

42. The process according to claim 41, further comprising introducing the heated fuel cell exhaust gas stream into a gas turbine.

43. An electrical current generating system, comprising:

at least one fuel cell operating at a temperature of at least about 250°C;

a fuel cell heat recovery system coupled to the fuel cell;

at least one fuel-gas-delivery system coupled to the fuel cell; and

a gas turbine system coupled to the fuel cell heat recovery system and the fuel-gas-delivery system.

44. The system according to claim 43, wherein the fuel cell is operated at a temperature of at least about 600°C.

45. The system according to claim 43, wherein the fuel cell heat recovery system comprises a recirculation conduit for carrying a heat recovery working fluid for transferring heat energy from the fuel cell to gas expansion energy for the gas turbine system.

46. The system according to claim 45, wherein the heat recovery working fluid is thermally coupled to a fuel cell exhaust gas stream.

47. The system according to claim 43, wherein:

the fuel-gas-delivery system comprises a pressure swing adsorption module; and

the gas turbine system comprises at least one pump or compressor coupled to the pressure swing adsorption module, and an expander coupled to the pump or the compressor.

48. The system according to claim 47, wherein the pressure swing adsorption module can produce an oxygen-enriched gas stream for delivery to the fuel cell.

49. The system according to claim 47, wherein there is a first pressure swing adsorption module that can produce an oxygen-enriched gas stream for delivery to the fuel cell and a second pressure swing adsorption module that can produce a hydrogen-enriched gas stream for delivery to the fuel cell.

50. An electrical current generating system, comprising:

at least one fuel cell selected from a molten carbonate fuel cell or a solid oxide fuel cell;

a fuel cell heat recovery system coupled to the fuel cell;

at least one fuel-gas-delivery system coupled to the fuel cell; and

a gas turbine system coupled to the fuel cell heat recovery system and the fuel-gas-delivery system.

51. An electrical current generating system, comprising:

at least one fuel cell defining at least one inlet for receiving a fuel gas stream and at least one outlet for discharging a fuel cell exhaust gas stream, the fuel cell operating at a temperature of at least about 250°C;

at least one fuel gas delivery system for delivering the fuel gas stream to the fuel cell inlet;

a gas turbine system coupled to the fuel gas delivery system;

a first conduit fluidly communicating with the fuel cell outlet for carrying the fuel cell exhaust gas stream;

a second conduit for carrying a heat recovery working fluid and fluidly coupled to the gas turbine system; and

a first heat exchanger housing a first portion of the first conduit and a first portion of the second conduit.

52. The system according to claim 51, wherein the fuel cell is operated at a temperature of at least about 600°C.

53. The system according to claim 51, wherein:

the fuel gas delivery system comprises a pressure swing adsorption module that can produce an oxygen-enriched gas stream for delivery to a fuel cell cathode inlet; and

the gas turbine system comprises at least one pump or compressor coupled to the pressure swing adsorption module, and an expander coupled to the pump or the compressor, the expander defining an inlet for receiving the heat recovery working fluid.

54. The system according to claim 53, wherein the electrical current generating system further comprises an air source for delivering air to the pressure swing adsorption module and to the second conduit as the heat recovery working fluid.

55. The system according to claim 51, wherein the first conduit and the second conduit are proximally disposed within the heat exchanger such that heat is transferred from the cathode exhaust gas in the first conduit to the heat recovery working fluid in the second conduit.

56. The system according to claim 51, wherein:

the fuel gas delivery system comprises a pressure swing adsorption module that can produce a hydrogen-enriched gas stream for delivering to a fuel cell anode inlet; and

the gas turbine system comprises at least one pump or compressor coupled to the pressure swing adsorption module, and an expander coupled to the pump or the compressor, the expander defining an inlet for receiving the heat recovery working fluid.

57. The system according to claim 56, further comprising a hydrogen gas generating system coupled to the pressure swing adsorption module, the hydrogen gas generating system defining an outlet for delivering a hydrogen-containing gas feed stream to the pressure swing adsorption module and an inlet for receiving a hydrocarbon fuel.

58. The system according to claim 55, further comprising a third conduit fluidly communicating with the hydrogen gas generating system inlet that can carry the hydrocarbon fuel, a fourth conduit fluidly communicating between the hydrogen gas generating system outlet and an inlet defined in the pressure swing adsorption module for receiving the hydrogen-containing gas feed stream, and a second heat exchanger housing a portion of the third conduit and the fourth conduit, wherein the third conduit and the fourth conduit are proximally positioned such that heat is transferred from the hydrogen-containing gas feed stream in the fourth conduit to the hydrocarbon fuel in the third conduit.

59. The system according to claim 53, wherein the pump comprises a vacuum pump for extracting an oxygen-depleted gas stream from the pressure swing adsorption module and the fuel cell is operated at a temperature of at least about 600°C.

60. The system according to claim 51, wherein the fuel cell defines a first outlet for discharging a cathode exhaust gas stream and a second outlet for discharging an anode exhaust gas stream, and the first conduit carries the cathode exhaust stream, the electrical current generating system further comprising a third conduit that carries the anode exhaust gas system, a portion of the third conduit being housed in the first heat exchanger.

61. The system according to claim 51, further comprising at least one second heat exchanger housing a second portion of the first conduit and the second conduit, and wherein the gas turbine system includes at least two expander turbines and the second conduit fluidly communicates between the first heat exchanger, the second heat exchanger, and the two expander turbines.

62. The system according to claim 51, wherein:

the fuel cell comprises a solid oxide fuel cell or a molten carbonate fuel cell;

the fuel gas delivery system comprises a first rotary pressure swing adsorption module for delivering an oxygen-enriched gas stream to a fuel cell cathode inlet and a second rotary pressure swing adsorption module for delivering a hydrogen-enriched gas stream to a fuel cell anode inlet; and

the gas turbine system is coupled to the first rotary pressure swing adsorption module and the second rotary pressure swing adsorption module.

63. The system according to claim 51 wherein the fuel gas delivery system comprises a gas separation module that can produce a fuel-enriched gas stream for delivering to the fuel cell inlet.

64. A process for providing at least one fuel-enriched gas stream to at least one fuel cell operating at a temperature of at least about 250°C, comprising:

establishing a pressure swing in a fuel-containing gas stream under conditions sufficient for separating a fuel-enriched gas stream from the fuel-containing gas stream;

introducing the fuel-enriched gas stream into a fuel cell;

transferring heat from the fuel cell to a heat recovery working fluid; and

introducing the heat recovery working fluid into at least one apparatus for establishing the pressure swing.

65. The process according to claim 64, wherein the pressure swing establishing comprises pressure swing adsorption, the fuel-containing gas stream comprises air, the fuel-enriched gas stream comprises an oxygen-enriched gas stream, and the apparatus comprises a gas turbine.

66. The process according to claim 64, wherein the heat transferring comprises transferring heat from at least one fuel cell gas exhaust stream to the heat recovery working fluid.

67. The process according to claim 65, wherein the heat recovery working fluid expands during introduction into the gas turbine to power a compressor or pump that generates the pressure swing.

68. A process for providing at least one fuel-enriched gas stream to at least one of a molten carbonate fuel cell and a solid oxide fuel cell, comprising:

establishing a pressure swing in a fuel-containing gas stream under conditions sufficient for separating a fuel-enriched gas stream from the fuel-containing gas stream;

introducing the fuel-enriched gas stream into a fuel cell;

transferring heat from the fuel cell to a heat recovery working fluid; and

introducing the heat recovery working fluid into at least one apparatus for establishing the pressure swing.

69. A process for providing an oxygen-enriched gas stream to at least one of a molten carbonate fuel cell or a solid oxide fuel cell, comprising:

providing a first pressure swing adsorption module that can produce an oxygen-enriched gas stream for delivering to the fuel cell;

providing a gas turbine system coupled to the first pressure swing adsorption module; and

circulating a heat recovery working fluid stream through the gas turbine system, wherein a portion of the heat recovery working fluid stream is juxtaposed with at least one fuel cell exhaust gas stream.

70. The process according to claim 69, wherein the gas turbine system comprises at least one expander coupled to a compressor or pump, and the heat recovery working fluid is introduced into the expander.

71. The process according to claim 69, further comprising heating the oxygen-enriched gas stream prior to delivery to the fuel cell by juxtaposing a portion of the oxygen-enriched gas stream with at least one of the heat recovery working fluid stream and fuel cell exhaust gas stream.

72. The process according to claim 69, further comprising providing a second pressure swing adsorption module that can produce a hydrogen-enriched gas stream for delivering to the fuel cell, wherein the gas turbine system is further coupled to the second pressure swing adsorption module.

73. An electrical current generating system, comprising:

at least one of a molten carbonate fuel cell or a solid oxide fuel cell; and

a pressure swing adsorption module coupled to the fuel cell that can produce a hydrogen-containing gas for delivery to the fuel cell, the pressure swing adsorption module including a first adsorbent and at least one second material selected from a second adsorbent and a steam reforming catalyst or water gas shift reaction catalyst.

74. The system according to claim 73, wherein the first adsorbent preferentially adsorbs carbon dioxide compared to water vapor.

75. The system according to claim 74, wherein the pressure swing adsorption module includes at least one first zone and at least one second zone, the first zone including the first adsorbent.

76. The system according to claim 75, wherein the first adsorbent comprises an alkali-promoted material and the catalyst comprises a Cu-ZnO catalyst, a transition metal carbonyl complex catalyst, or a catalyst comprising a transition group metal inserted into a zeolite cage.

77. The system according to claim 75, further comprising a third zone that includes at least one desiccant.

78. The system according to claim 74, wherein the catalyst is included in at least one of the first or second zone.

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79. The system according to claim 80, wherein the alkali-promoted material is selected from alumina impregnated with potassium carbonate, hydrotalcite promoted with potassium carbonate, and mixtures thereof.

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